Indirect and diffusive pumping for magnetometry applications

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Sensing has emerged as one of the primary applications of hot alkali-metal vapours. In particular magnetometry can achieve extreme sensitivities thanks to high atomic density and long ground state coherence times. The work at NPL has focused on radio-frequency sensors, which have recently demonstrated sensitivities at the 30 aT/Hz^1/2 level [1] and a range of applications from biomedical sensing [2], chemical detection [3], and non-destructive testing [4]. The group is actively researching the later; an industrial application that presents a potential high-volume market, which would be required to scale the development of components required for atomic sensors generally, e.g. narrow linewidth lasers and atomic vapour cells.

Atomic spin polarization lies at the heart of these sensors, and we have demonstrated some of the advantages of using indirect pumping, a process that combines optical excitation and spin-exchange collisions [5]. The benefits include the continuous generation of spin orientation with a light field that is decoupled from the spin state, limiting decoherence effects from power broadening.

Two methods to mitigate spin depolarisation through collisions with the vapour cell walls are to use antirelaxation coatings or fill the cell with an inert buffer gas. Although the concept of indirect pumping was developed in paraffin coated cells, where atomic spatial dynamics of a dilute vapour are ballistic, we recently demonstrated equivalent behaviour in buffer gas cells [6]. These cells exhibit diffusive pumping, a process that occurs in a dense vapour where the optical path length is significantly less than the cell and spin polarisation is dominated by spin exchange. This talk will cover the development of indirect pumping along with some recent demonstrations of its implementations in the field of atomic magnetometry and outline how diffusive pumping is important in co-magnetometers [7].

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